AGE EFFECT ON AUTONOMIC CARDIOVASCULAR CONTROL IN PILOTS

R. Nikolova*, S. Danev*, R. Nantcheva, M. Vukov*****

*National Center of Hygiene, Medical Ecology and Nutrition
15 Dimitar Nestorov Blvd.
1431 Sofia, Bulgaria

**Military Medical Academy
Institute of Aviation Medicine
3 St. Georgi Sofiisky Str.
1606 Sofia, Bulgaria

***National Center of Health Informatics
15 Dimitar Nestorov Blvd.
1431 Sofia, Bulgaria

ABSTRACT

The autonomic cardiovascular control was determined as a function of age in 66 military pilots and in 39 referents, both groups aged from 20 to 55 yr. It was assessed by time-domain and frequency-domain heart rate variability (HRV) measures and with some HRV-derived indices. Most sensitive to aging process from time-domain HRV measures revealed to be short-term variability and time-domain index, and from frequency-domain HRV measures frequency-domain index. The activity of both ANS branches was found to decline with age, but a different extent of decrease of sympathetic as compared to parasympathetic activity was observed: sympathetic activity reflected by the spectral power of the R-R intervals in the temperature - mediated spectral frequency band (0.01-0.05 Hz) decline more slowly than parasympathetic activity reflected by respiratory sinus arrhythmia - mediated spectral frequency band (0.15-0.50 Hz). As well as such age-desynchronized autonomic cardiovascular control was found only in military pilots but not in referents it is concluded that the aging process in pilots is accelerated due to repetitive and prolonged exposure to persisting stress, caused by the compulsory underload (substantial reduction of flying tasks and physical exercises coinciding with personal interviews). Although the computed Overall Health Risk values in both groups were not substantially deviated from "normal", those in military pilots was significantly higher.

INTRODUCTION

Aging process is accompanied with regular changes in the repair and maintenance of most physiological functions. Functional response integrity and its adaptive capacity are affected by age. During aging process physiological functions perturb different extent of changes.
Age-associated neural, receptor and end-organ changes modify integration and regulation of cardiovascular responses. Mechanisms governing cardiovascular regulation, involve in part autonomic influences.

Considerable interest exists on the effects of age on the Autonomic Nervous System (ANS) that raises the question how to measure autonomic function quantitatively. Heart rate fluctuations are result of reciprocal control of the sympathetic and parasympathetic activities. As normal variations in resting heart rate are due to the tonic changing levels of activity of both ANS divisions, Heart Rate Variability (HRV) has been the focus of previous and recent studies on the effect of age on the ANS. HRV is a noninvasive method for assessment of autonomic nerve activity. Three components of HRV are involved in the autonomic control of heart rate fluctuations:

HRV Components

1. Temperature component of heart rate fluctuations in the frequency band: 0.01 - 0.05 Hz, related to thermoregulatory and peripheral vascular mechanisms, mediated by sympathetic activity (2; 26).

2. Traube-Hering-Mayer wave component of heart rate fluctuations in the frequency band: 0.06 - 0.14 Hz, reflected short-term blood pressure regulation, jointly mediated by sympathetic and parasympathetic activities (2; 35; 45).

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3. Respiratory Sinus Arrhythmia (RSA) component of heart rate fluctuations in the frequency band 0.15-0.50 Hz, reflected respiratory related fluctuations in heart rate variations, mediated by parasympathetic activity (2; 24; 45).

Aging process in military crew members could be magnified by repetitive and prolonged exposure to the stressful work environment or may be counterbalanced by the effect of training and expertise. Military pilots are exposed to different kinds of stressors in execution of their missions and stressors induced by work environment factors(1; 13; 17; 30; 31; 39; 46). Stress causes distracting and dysfunctional activation which prolongs after completing of the mission tasks (15). A number of studies have investigated the impact of the mission demands and simulated flight tasks on HRV components (17; 57; 60). However age effect on autonomic cardiovascular control in military pilots is not described in full.

Available studies in cardiovascular psychophysiology are devoted to the controversial problem of the age effect on autonomic cardiac control in healthy subjects.

AGE EFFECT ON SYMPATHETIC AND PARASYMPATHETIC ACTIVITIES ASSESSED BY HRV IN HEALTHY SUBJECTS

Studies based on HRV analysis have focused on two alternative conceptualizations of age effects on sympathetic and parasympathetic activity, that both branches decline with age or that the relative dominance of the two branches changes with age.

First Conceptualization

First conceptualization concerning the age effect on autonomic cardiovascular control elucidates that both sympathetic and parasympathetic activities decline with age. Aging is characterized by an impaired autonomic modulation which is reflected by reduction of the spectral powers of the HRV components: temperature-, T-H-M wave and RSA bands. The decreasing of spectral power of temperature component (which depends largely upon adrenergic activity) and spectral power of RSA component (which is a marker of parasympathetic function) with age are attributed to decline in efferent vagal cardiac tone and decreased adrenergic responsiveness associated with increased age (11; 14; 52; 53; 56). Except declining of the spectral powers in these HRV components in the Atherosclerosis Risk in Communities Study it was found that their spectral ratio also is inversely associated with age (age range: 45-64 yr) (32). These findings have been reported in other studies including examination of time-domain HRV measures and have been discussed as declining of parasympathetic and sympathetic influences mediating HRV components with increasing age (23; 33; 40; 56). The temperature component, the RSA component and the temperature-/RSA-band ratio (currently considered the spectral marker of sympathetic activity) diminish with age (age range: 25-85 yr) but distinction of previous results is a more pronounced age-related decline in sympathetic activity that begins about the sixth decade of life (34; 44). In young people a trend of predominating vagal tone was observed but in the elderly the respective decreases of sympathetic and parasympathetic components are of an almost similar importance (50). Age-associated decline in autonomic function has been confirmed by the inverse relation of RSA, T-H-M wave HRV components and peak O_2 consumption with age (7; 55); and by inverse relation of HRV spectral components, and baroreflex sensitivity with age (29).

Sensitivity of the quantitative assessment of the autonomic abnormalities in aging increases with studies involving postural manipulations. The spectral powers in temperature band (depending on adrenergic activity), the temperature-/ RSA-band ratio (marker of sympathetic activity) and the total spectral power of HRV diminish with age and appear depressed in the elderly subjects after postural tilt-testing (28; 51; 61). Reduction with advancing age of the T-H-M wave (0.10 Hz variability) and the RSA component after postural change indicate the depressed activity of sympathetic cardiac nerve activity, reduced cardiac vagal modulation and impaired baroreflex sensitivity at upright rest in older subjects (7; 42; 48). Contrary when uses gradual orthostatic load testing in the young adult (20-35 yr) and late middle-aged (50-66 yr) groups, the average values of the sympathovagal transition were almost equal (5).

Several cardiovascular reflex tests have been used to assess the dependence of autonomic function on age. Examination of the cardiac reflex tests (mean value of R-R intervals at normal and deep breathing; ratio of the R-R intervals at maximal tachycardia to R-R intervals at body tilt; orthostatic ratio of the R-R intervals at 30/13 s; heart rate reaction at Valsalva ratio) show significant negative correlation of HRV with increasing age (43). Cardiovascular responses to specified tests have been utilized as they are known to be mediated by autonomic control.

Second Conceptualization

Second conceptualization concerning the age effect on autonomic cardiovascular control elucidates that the relative dominance of the sympathetic and parasympathetic activities changes with age. Aging affects cardiac autonomic control as reduces the relative dominance of parasympathetic nervous system in controlling rhythmic variations of resting heart rate (18; 48; 49). The relative ratio of parasympathetic to sympathetic activity in supine rest is 6:1; for young and middle-aged groups the ratio is 9:1, resp. 3:2 (48; 49). The decreasing of HRV has been attributed to

diminished vagal activity accompanying aging (25; 36). Strong evidence for declining of parasympathetic activity is the change of RSA component of HRV. An inverse linear relationship between the RSA amplitude and age (21-54 yr) has been found (18) but no further decrease in RSA has been observed after age 50 yr in normal subjects (59). The inverse relationship of RSA and age has been confirmed, where RSA amplitude rapidly decreases from 20 to 35 yr and then shows no further decrease up to 78 yr (19). The RSA amplitude falls approximately 10 percent per decade (20). Pronounced reduction of respiratory related heart rate oscillations in the frequency range (0.15-0.40 Hz) compared with preserved vasomotor rhythms is found (38).

Contrary to these findings other studies suggest the theses of age-associated declining or increasing of relative dominance of sympathetic activity in autonomic cardiac control. Relatively larger decline has observed in the temperature- , and the T-H-M wave HRV components (related to thermoregulatory, vasomotor and renin-angiotensin control mechanisms) compared to respiratory component (22). In contrast to the observed decline in the temperature- and the T-H-M wave HRV components, an increasing of the temperature-/the RSA ratio (spectral marker of the sympathetic activity) and the spectral power in the temperature band (currently considered sympathetically mediated) in another studies are attributed to increase in relative dominance of the sympathetic influence in autonomic cardiac control with age (8; 61; 62).

In summary it can be stated that changes of the parasympathetic and sympathetic mediation of heart rate are important determinants of age dependence of HRV and are involved in the age genesis of the HRV components. Aging may cause opposite effects on the autonomic functioning: reduction of both sympathetic and parasympathetic tone; pronounced attenuation of the predominance of the parasympathetic activity and/or declining, resp. increasing of the relative dominance of the sympathetic activity. These data indicate that the problem of whether both sympathetic and parasympathetic tone is changed to the same extent with age is controversial.

Examination of the age-associated ANS functioning will contribute to the clarifying of the effect of aging on sympathetic and parasympathetic branches of the ANS in military pilots.

The aim of the present study was to determine the functional role of the autonomic cardiovascular control as a function of age in military pilots.

Determination of age-modified autonomic control in military pilots would help to understand whether stressful work environment would alter the pattern of normal aging process.

This study will test the hypothesis that the functional role of the autonomic cardiovascular control is changed as a function of age. The proposition inherent in this hypothesis is that a cause-effect relationship exists between age-modified autonomic control and cardiovascular function.

METHODS

Subjects

Two groups of subjects participated in this study: military pilots and referents (employees). First group consisted of 66 male military pilots employed by the Bulgarian Military Air Force and students of the Bulgarian Military Air Academy whose ages ranged from 20 to 55 years (mean age X±SD 34.85±10.71). Referent group consisted of 39 male subjects who were employees in institutions matched for age (X±SD 34.13±11.00; age range: 20 to 55 yr) to the military pilots.

Criteria for exclusion included: systolic blood pressure>130 mmHg; diastolic blood pressure>85 mmHg; body-mass index>25 kg/m$^{2;}$ smoking; using medications; diabetes; cholesterolaemia; and a history or evidence of cardiovascular, respiratory, renal, hepatic, gastrointestinal or systemic disease.

Procedure

HRV data were determined from 10 min ECG recordings between 9 a.m. and 11 a.m. in supine position after 1 h rest period. HRV data were obtained in three consecutive days and mean individual values from the measurements were calculated.

Heart Rate Variability

Computerized method for analyzing of HRV was applied (12). An ECG was registered from a bipolar standard Ist lead.

A portable electronic device was used to transform ECG signal into R-R intervals and to emit (transmit) R-R intervals to IBM compatible PC for on-line processing. ECG signal is transformed to R-R intervals by AC converter (QRS detector and timer, resolution time 2224 samples per second). This sampling rate gives a variation of 0.48 msec in locating the peak of R-wave and results in a minimum accuracy of 99.55 % in computing heart rate up to 140 beats/min.

Time-domain and frequency-domain HRV measures, and HRV derived indices were analyzed:

1. Time-domain HRV measures:

X (mean R-R interval) (msec), resp. mean heart rate (beats/min); Short-Term Variability (STV) (msec) (reflecting respiratory oscillations in heart rate variations); Long-Term Variability (LTV) (msec) (reflecting baroreceptory- and thermoregulatory influences on heart rate variations); Time-Domain Index (TDI) (arb. un.) (assessing sympathetic/parasympathetic influences on histogram R-R intervals distribution).

2. Frequency-domain HRV measures:

Spectral power of the R-R intervals in the Temperature band (0.01-0.05 Hz) (P_T) (ms^2) (sympathetically mediated); spectral power of the R-R intervals in the Traube-Hering-Mayer band (0.06-0.14 Hz) (P_{THM}) (ms^2) (sympathetically and parasympathetically mediated); spectral power of the R-R intervals in the Respiratory Sinus Arrhythmia (RSA) band (0.15-0.50 Hz) (P_{RSA}) (ms^2) (parasympathetically mediated); Frequency-Domain Index (FDI) (P_T/P_{RSA}) (arb. un.) (reflecting sympathetic/parasympathetic activity ratio). Spectral powers of the R-R intervals in the respective frequency bands were calculated using Fast Fourier Transform.

3. HRV-derived indices:

Physical Stress (PS) (arb. un.) (mathematical algorithm based on difference between measured and age-referent values derived from the time-domain HRV measures); Mental Stress (MS) (arb. un.) (mathematical algorithm based on difference between measured and age-referent values derived from the frequency-domain HRV measures); Functional Age (FA) (yr) (mathematical algorithm computing difference between measured and age-referent values of autonomic activity derived from the frequency-domain HRV measures); Health Risk (%) (mathematical algorithm derived from PS-, MS-coefficients and number of premature heart beats).

Analysis of Data

HRV measures, HRV-derived indices and heart rate in referent and in military pilots groups are expressed as means ± standard deviations. Means of HRV variables were compared by independent samples t-test. To define correlations between age and HRV variables bivariate correlation analysis was applied (in referent group Pearson's correlation analysis; in military pilots group Spearman's correlation analysis). In referent group correlation analysis of Pearson was used as all variables including age were normally distributed. In military pilots group correlation analysis of Spearman was used as age was not normally distributed variable. Linear regression analysis was performed using age as independent variable and the measures of HRV as dependent variables. Logistic regression analysis (method forward: LR) was used to define which measures discriminate two groups of subjects. A p value lesser 0.05 was considered statistically significant.

RESULTS

I. Stress Differences

To examine whether military pilots and employees are exposed to stress influence in their jobs HRV measures were compared between both groups by independent samples t-test. HRV is a sensitive method for determination of disturbed autonomic function induced by stress factors of work environment (1; 12; 37). Mean values of HRV variables in both groups are presented in Table 1.

Table 1. Mean groups (X ± SD) and p-values of time- and frequency-domain HRV measures, HRV-derived indices, heart rate and age.

Variables	Referent group X ± SD	Military pilot group X ± SD	P-value
Age	34.13 ± 11.00	34.85 ± 10.81	n.s.
Heart rate (b/min)	72.3 ± 10.36	76.6 ± 10.71	0.04
STV (msec)	48.90 ± 16.38	52.77 ± 22.27	n.s.
LTV (msec)	37.92 ± 13.07	40.82 ± 14.53	n.s.
TDI (arb.un.)	69.21 ± 27.24	46.06 ± 17.83	<0.0001
X (msec)	846.18 ± 121.87	798.33 ± 112.83	0.04
$P_{(T)}$ (ms^2)	7.16 ± 2.83	9.29 ± 3.80	0.003
$P_{(THM)}$ (ms^2)	10.55 ± 3.82	11.79 ± 6.68	n.s.
$P_{(RSA)}$ (ms^2)	12.0 ± 5.55	8.76 ± 5.05	0.003
FDI (arb.un.)	38.86 ± 13.38	33.92 ± 14.54	n.s.
PS (arb.un.)	-0.76 ± 0.11	0.48 ± 0.08	<0.0001
MS (arb.un.)	0.43 ± 0.16	1.12 ± 0.24	0.01
HR (%)	25.82 ± 10.59	41.26 ± 22.08	<0.0001
FA (yr)	33.13 ± 8.79	36.70 ± 11.38	n.s.

Stress caused significant decrease of mean values of P_{RSA}, TDI and mean R-R interval in pilots compared to referents. Stress resulted also in significant increase of mean values of P_T, PS, MS, HR and heart rate in pilots. Fig. 1, fig. 2 and fig. 3 illustrate differences in mean values of P_T and P_{RSA}; MS and resp. HR in both groups.

Fig. 1. Mean values of the $P_T(ms^2)$ and $P_{RSA}(ms^2)$ in referent and military pilots groups.

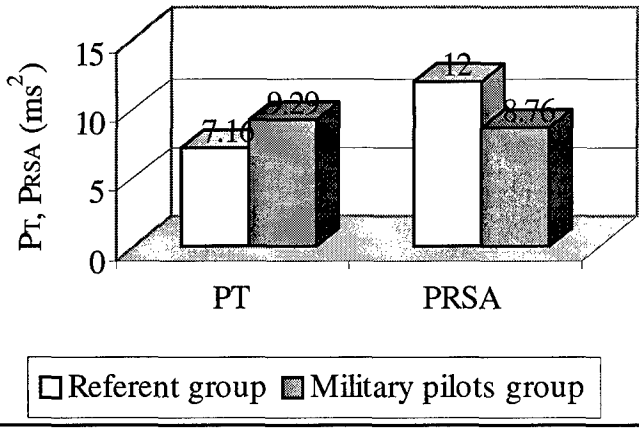


Fig. 2. Mean values of the MS (arb.un.) in referent (I) and military pilots (II) groups.

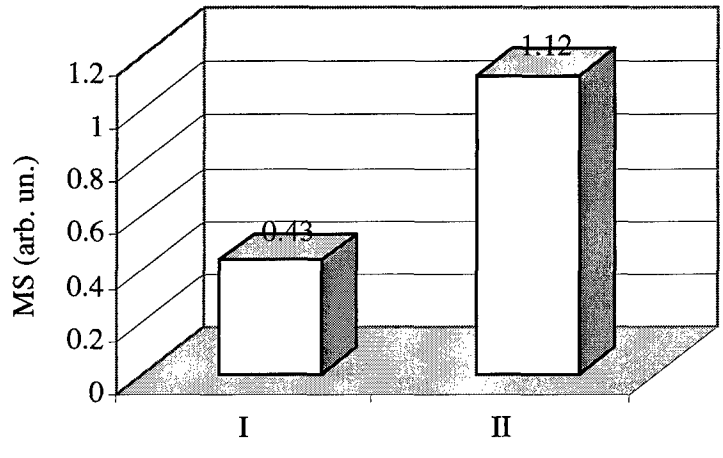
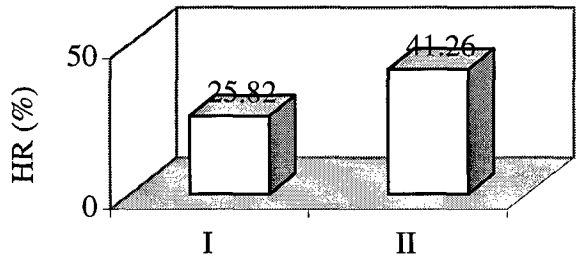


Fig. 3. Mean values of the HR (%) in referent (I) and military pilots (II) groups.



Logistic regression analysis (method forward: LR) (3) contributed for discrimination of pilots exposed to stressful demands of work environment from referents who were not exposed to stress impact. Four variables: STV, TDI, mean R-R interval and P_{RSA} thought sympathetically and parasympathetically mediated discriminate pilots of referents in this study (fig. 4). Probability one investigated subject to refer to referent group is assessed by first equation in fig. 4. Then, the probability of investigated subject to be a pilot is assessed by a second equation in fig. 4. The general discrimination power was 98.10 %, all pilots were correctly classified with exception of two referents.

Fig. 4. Equations of the logistic regression analysis (method forward: LR).

$$P(CC=0)=\frac{1}{1+e^{-(26.54+1.35STV-1.688TDI-0.026X+0.954P_{RSA})}}$$

$$P(CC=1)=1-P(CC=0)$$

0 - referent group
1 - military pilots group

These results may indicate that:

- Military pilots are exposed to stress factors of work environment. Stress affects autonomic cardiovascular control in pilots.
- STV, TDI, X (mean R-R interval) and P_{RSA} are recommendable to be used for psychophysiological selection of pilots.

II. Age Effect on Autonomic Cardiovascular Control.

The effect of age on autonomic cardiovascular control was determined by correlation and linear regression analyses.

1. Correlations of Age with HRV

In military pilots were observed:

- Significant negative correlation of age with time-domain HRV measures: STV (r=-0.55, p<0.0001); LTV (r=-0.53, p<0.0001) and TDI (r=-0.59, p,0.0001).

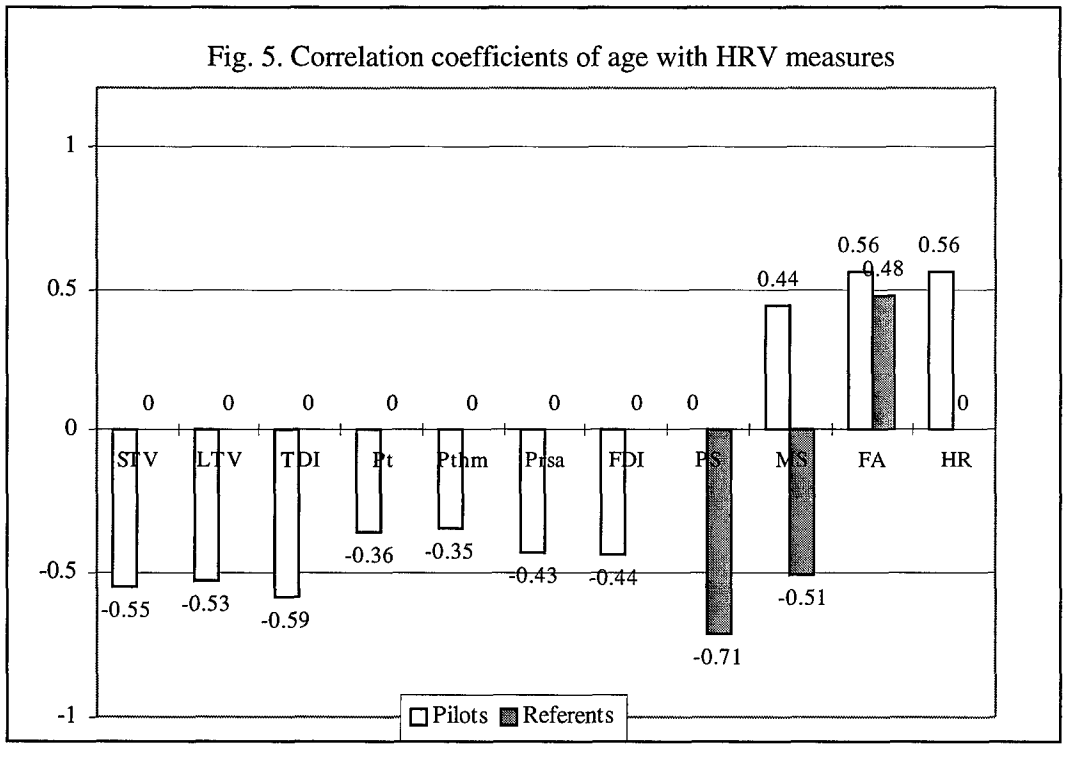
Mean R-R interval (X), resp. heart rate was unrelated to age.

- Significant negative correlation of age with frequency-domain HRV measures: P_T (r=-0.36, p<0.001); P_{THM} (r=-0.35, p<0.001); P_{RSA} (r=-0.43, p<0.0001) and FDI (r=-0.44, p<0.0001).
- Significant positive correlation of age with HRV-derived indices: MS (r=0.44, p<0.0001); FA (r=0.56, p<0.0001) and HR (r=0.56, p<0.0001).

In referent group significant correlations were observed between age and PS (r=-0.71, p<0.0001); MS (r=-0.51, p<0.001) and FA (r=0.48, P<0.0001).

Correlation coefficients of age with HRV variables in military pilots and referents are presented in fig. 5.

Fig. 5. Correlation coefficients of age with HRV measures



2. Age Dependencies of HRV

Autonomic cardiovascular control assessed by HRV declines progressively as a function of age in pilots. This pattern was observed for both time- and frequency-domain HRV measures.

- Time-domain HRV measures: STV and TDI decreased markedly with age while (whereas) LTV decreased more gradually with age. Regression coefficients are presented in table 2.
- Frequency-domain HRV measures: Differentiated spectral powers of R-R intervals in the respective frequency bands declined slowly with advancing age compared with time-domain HRV measures. Slowest extent of age decline showed P_T. Contrary to the slow decline of P_T, P_{THM} and P_{RSA}, FDI (P_T/P_{RSA}) demonstrated rapid decline with aging. Regression coefficients are presented in table 2.
- HRV-derived indices: In contrast to HRV measures MS, HR and FA increased progressively with advanced age. Regression coefficients are presented in table 2.

Table 2. Significant regression coefficients of dependence of age on HRV.

Variables		Referent group	Military pilot group
Time-domain HRV measures			
	STV	-	-1.00***
	LTV	-	-0.72***
	TDI	-	-0.97***
Frequency-domain HRV measures			
	FDI	-	-0.62***
	P_T	-	-0.09***
	P_{THM}	-	-0.20***
	P_{RSA}	-	-0.21***
HRV-derived indices			
	PS	-0.04***	0.04***
	MS	-0.03***	1.01***
	HR	-	1.15***
	FA	0.77***	1.01***
X (mean R-R)		-	-
Heart rate		-	-

***p<0.0005

In referents significant regression coefficients of dependence of age on HRV were observed for FA, PS and MS. Regression coefficients are presented in table 2.

3. Association of Health Risk with HRV measures

Although the Health Risk (HR) values were normal among both groups, HR was significantly increased in military pilots compared with referents (table 1 and fig. 3).

Age-modified autonomic cardiovascular control in military pilots was related to health risk. Correlation of age with HR is r=0.56, p<0.0001. Significant correlations were observed between HR and time-domain HRV measures: STV (r=-0.83, p<0.0001), LTV (r=0.71, p<0.0001), TDI (r=0.86, p<0.0001); and frequency-domain HRV measures: FDI (r=0.83, p<0.0001), P_T (r=0.45, p<0.0001), P_{THM} (r=0.72, p<0.0001), P_{RSA} (r=-0.86, p<0.0001).

In referent group significant correlations of HR with HRV measures were not observed.

DISCUSSION

Autonomic cardiovascular control examined by HRV measures and HRV-derived indices changed as a function of age in military pilots. Both sympathetic and parasympathetic mediated HRV measures: time-domain measures (STV, LTV and TDI) and frequency-domain measures (P_T, P_{THM}, P_{RSA} and FDI) declined with advancing age. The most sensitive changes to aging process revealed STV (thought to reflect respiratory sinus arrhythmia) (12; 47), TDI (thought to reflect sympathetic/parasympathetic influences on histogram R-R intervals distribution) (12) and FDI (thought to represent ratio of sympathetic/parasympathetic modulation on R-R intervals) (12).

Our results revealed that both ANS divisions declined with age but we observed different extent of decreasing of sympathetic and parasympathetic determinants involved in the age genesis of HRV components. It is important to note that the observed by us dependencies of age on HRV measures (assessed by linear regression analysis) are valid only for age range 20-55 yr.

Sympathetic activity mediating P_T declined more slowly with increasing age than parasympathetic activity mediating P_{RSA}. This pattern was observed also for age-associated LTV change. Compared to STV and TDI, LTV decreased more slowly with advancing age. In contrast to parasympathetically mediated RSA explaining STV change, LTV represents baroreflex- and thermoregulatory-related HRV that are sympathetically and parasympathetically mediated. This result is consistent with finding of Korkushko et al. (27) who reported a different pattern of impairment of sympathetic and parasympathetic tone: power in high-frequency band (0.2-0.4 Hz) declines from the

middle of the third decade of life whereas power in low-frequency band (0.01-0.05 Hz) declines linearly after age 50 yr.

More likely mechanisms for observed of us age-associated decline of both ANS divisions are decreased baroreceptor sensitivity, baroreceptor modulation of heart rhythm and blunted beta-adrenergic influences on the myocardium and vasculature. Age-associated desynchronized autonomic cardiovascular functioning might be accelerated by repetitive and prolonged exposure to persisting stress induced by underload effect on Bulgarian military pilots. The underload is related to substantially reduced flying tasks. The role of compulsory flying reduction as a strong stressogenic factor was supported by the results of personal interviews which revealed also a remarkable decrease in the physical exercises. Similar mechanisms explaining age-related changes in cardiovascular control in response to stressors were reported (21; 67). To further elucidate the effect of age on autonomic cardiovascular control under stress it would be important to extend our study with simultaneous analysis of factors underlying heart rate change as: cardiac output, total peripheral resistance, baroreflex sensitivity.

Our study did not reveal significant correlation or dependence of age with/on mean R-R interval, resp. mean heart rate. The most likely reason might be not strong enough level of stress. Correlation of age with heart rate might be observed in conditions of high overload (overstress) or acute stress. The other reason might be relatively modest heart rate change yielded by age-associated co-inhibited sympathetic and parasympathetic activities. Our study revealed significant dependence of age on PS. PS in military pilots increased with age as they possessed higher level of physical training than referents. The opposite dependence was observed in referents due to low level of training.

Vagal and sympathetic nerve activities are coordinated to achieve balanced operation of the cardiac rhythm. However the function of the ANS is not only a fixed reciprocal reaction but changes according to the stimuli or situations (4).

Our main finding concerning the functional response of age-desynchronized autonomic cardiovascular control in military pilots might be affected on:

- Pattern of acceleration of aging process in military pilots. The most likely mechanism for aging acceleration in military pilots is repetitive and prolonged exposure to persisting stress induced by underload. The underload is due to the substantial reduction of flying tasks. Flying tasks are reduced according to the specific economic situation in our country. Repetitive and prolonged exposure to underload stress condition accelerates aging process. In referents such pattern was not observed. In referent group correlation or dependence of age with/on HRV measures was not observed. Age did not exert significant influence on autonomic cardiovascular control in referents in age range: 20 to 55 yr as they were not exposed to stress factors in their work activity.
- According to the doctrine of the autonomic space of Cacioppo et all. (8) and Berntson et all. (4) our finding referring to age-modified autonomic cardiovascular control can be defined as "coupled non-reciprocal (co-inhibition) mode of autonomic control" due to decline of both ANS branches as a function of age. Grossman et all. (16) indicate that stress affects sympathetic and parasympathetic cardiac function. Under stress effects sympathetic and parasympathetic activities can vary independently, not only reciprocally (4; 8). Our results in this respect indicated age-related co-inhibition (concurrent decreases) of both sympathetic and parasympathetic activity under stress.
- Although the Health Risk values among both groups were normal, military pilots revealed higher values of health risk compared with referents. This might be due to the slowly decline of sympathetic activity with age rather than parasympathetic activity. Parasympathetic activity decline rapidly with advancing age. Reduced HRV is associated with increased cardiovascular risk (54). Probability for development of hypertension and coronary artery disease (CAD) is increased when health risk is increased above 65 % (12). In military pilots increased incidence of CAD, arrhythmia's and hypertension was observed above 35 yr (9; 10; 13; 41; 46). However in our study exact and precise assessment of health cardiac risk in military pilots could be done only if additional clinical and paraclinical measures would be examined.

In conclusion our results in military pilots demonstrated:

1. Autonomic cardiovascular control assessed by HV measures changed as a function of age.
2. Both ANS branches declined with age but we observed different extent of decrease of sympathetic and parasympathetic activity. Sympathetic cardiac activity declined slowly with advancing age rather than parasympathetic activity.
3. Pattern of acceleration of aging process. The most likely mechanism for aging acceleration is repetitive and prolonged exposure to persisting stress induced by underload due to substantial reduction of flying tasks.

4. According to the doctrine of the autonomic space of Cacioppo et all. (8) and Berntson et all. (4) the examined age-associated autonomic cardiovascular control can be defined as "coupled non-reciprocal (co-inhibition) mode of autonomic control".
5. Although the health risk values among both groups were normal, military pilots revealed higher values of health risk compared with referents.

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